10/009075

FIG. 1

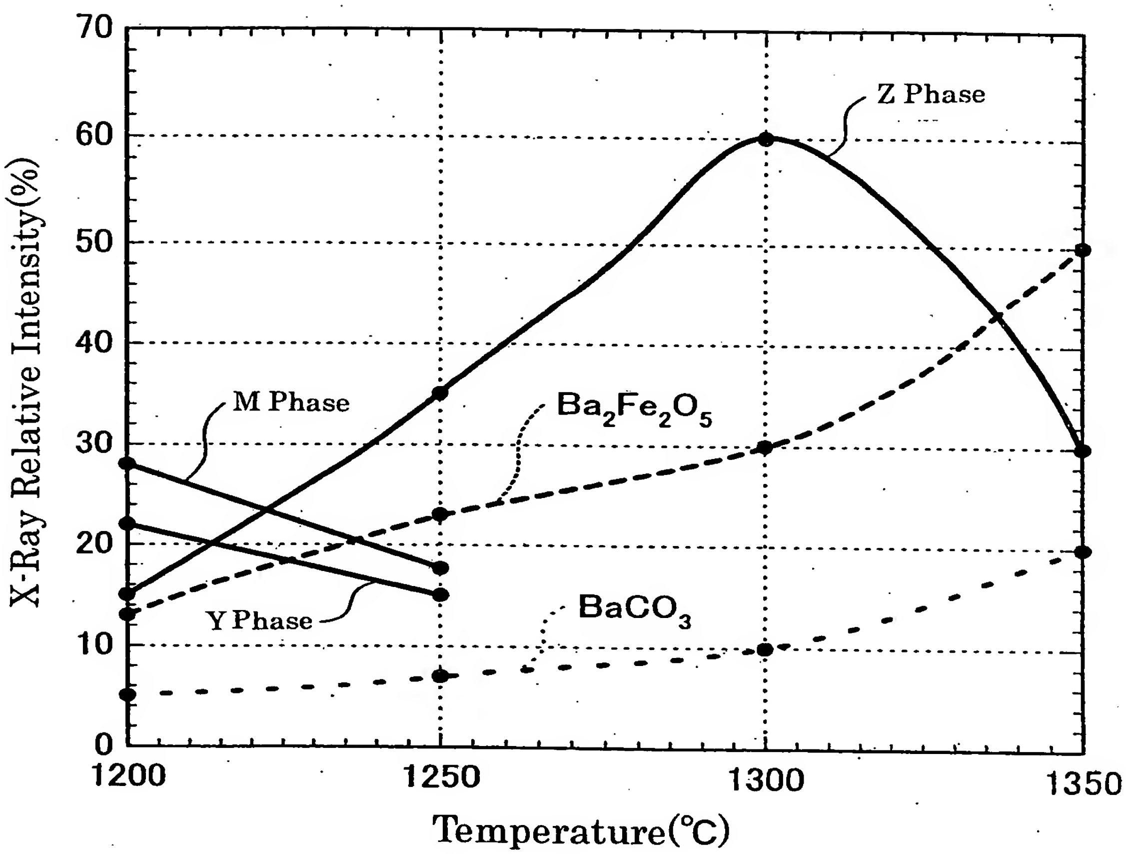


FIG. 2

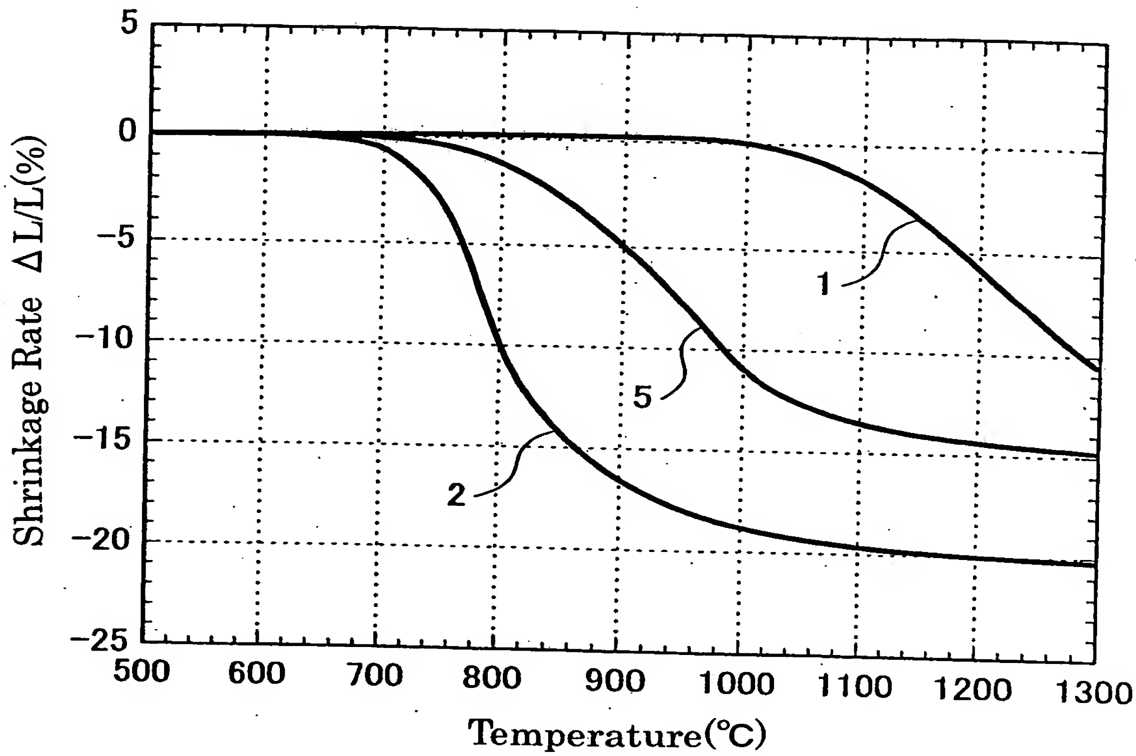

Shrinkage Rate ΔL/L(%)
5
0
−5
−10
−15
−20
−25
500
600
700
800
900
1000
1100
1200
1300
Temperature(℃)
1
5
2

FIG. 3

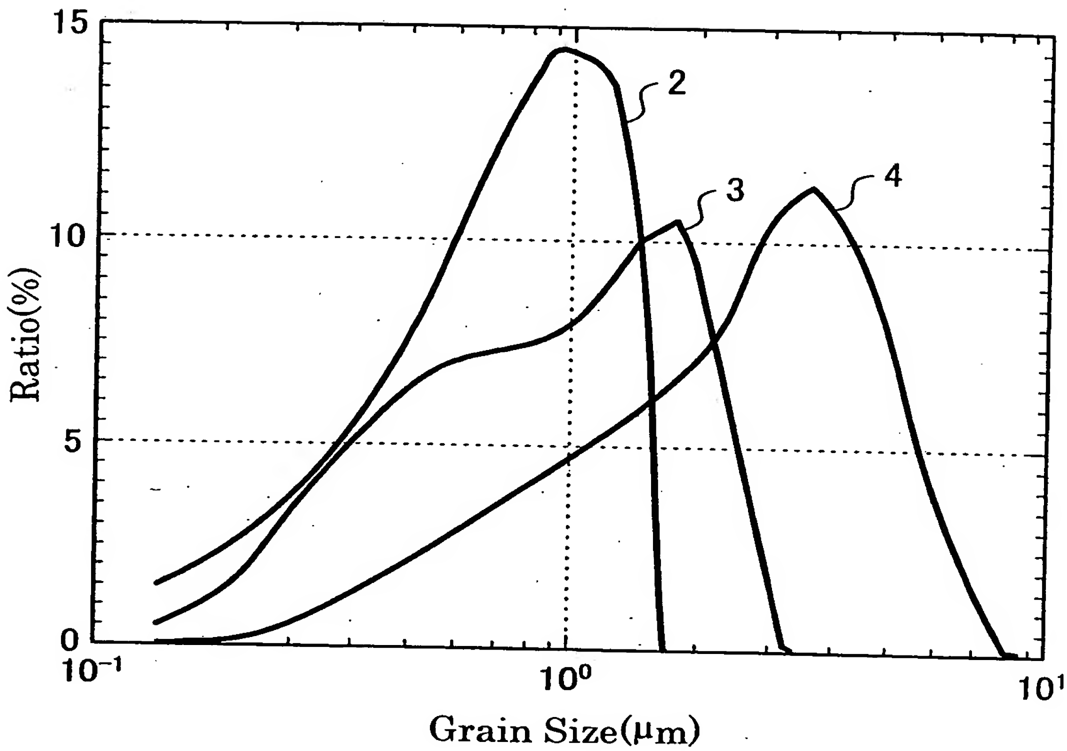


FIG. 4

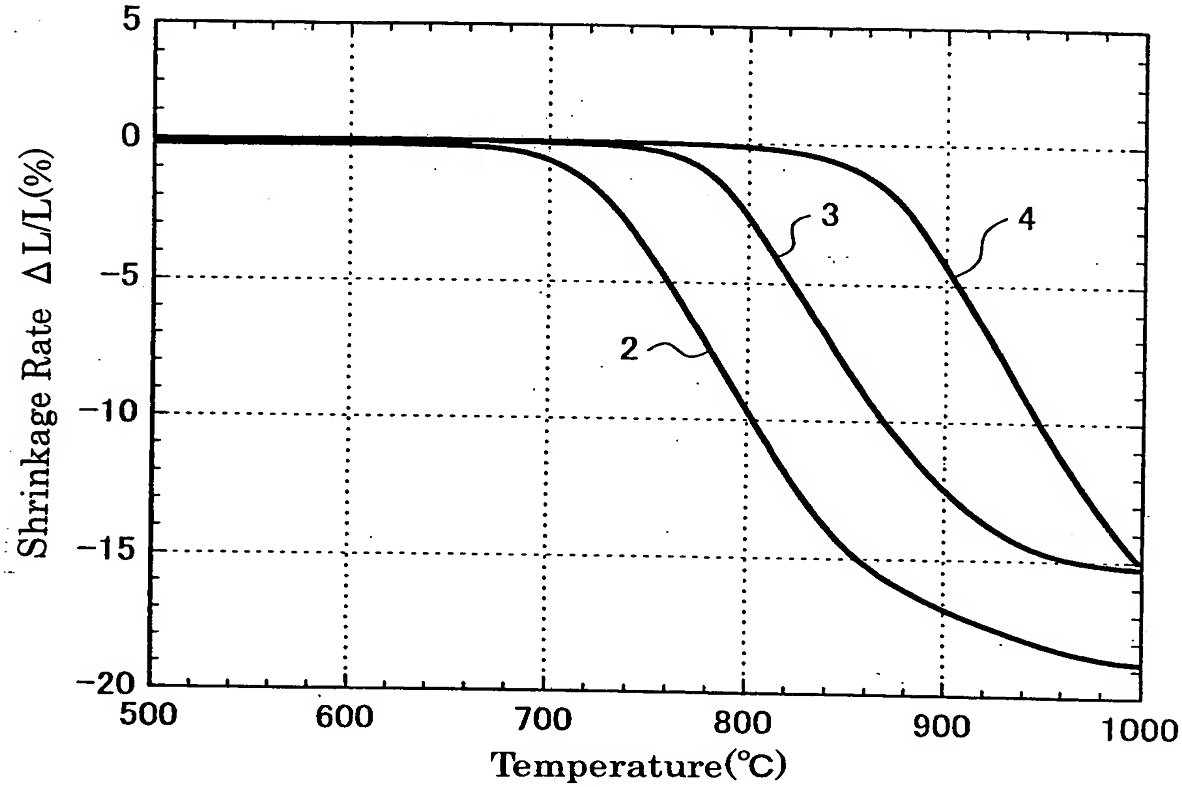

5
0
−5
−10
−15
−20
Shrinkage Rate ΔL/L(%)
500
600
700
800
900
1000
Temperature(℃)
2
3
4

FIG. 5

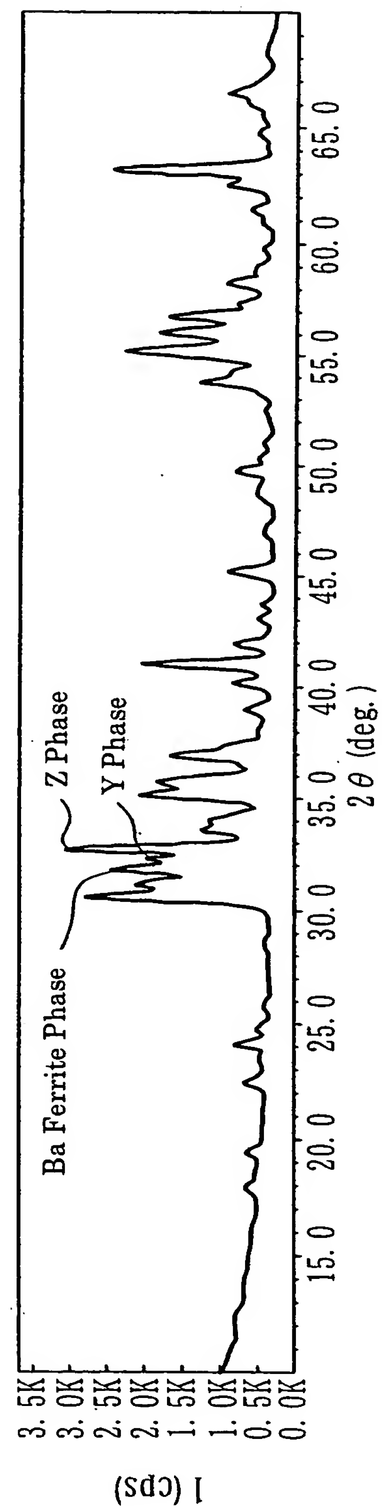

Ba Ferrite Phase
Z Phase
Y Phase
I (cps)
3. 5K
3. 0K
2. 5K
2. 0K
1. 5K
1. 0K
0. 5K
0. 0K
15. 0
20. 0
25. 0
30. 0
35. 0
40. 0
45. 0
50. 0
55. 0
60. 0
65. 0
2θ (deg.)

FIG. 6

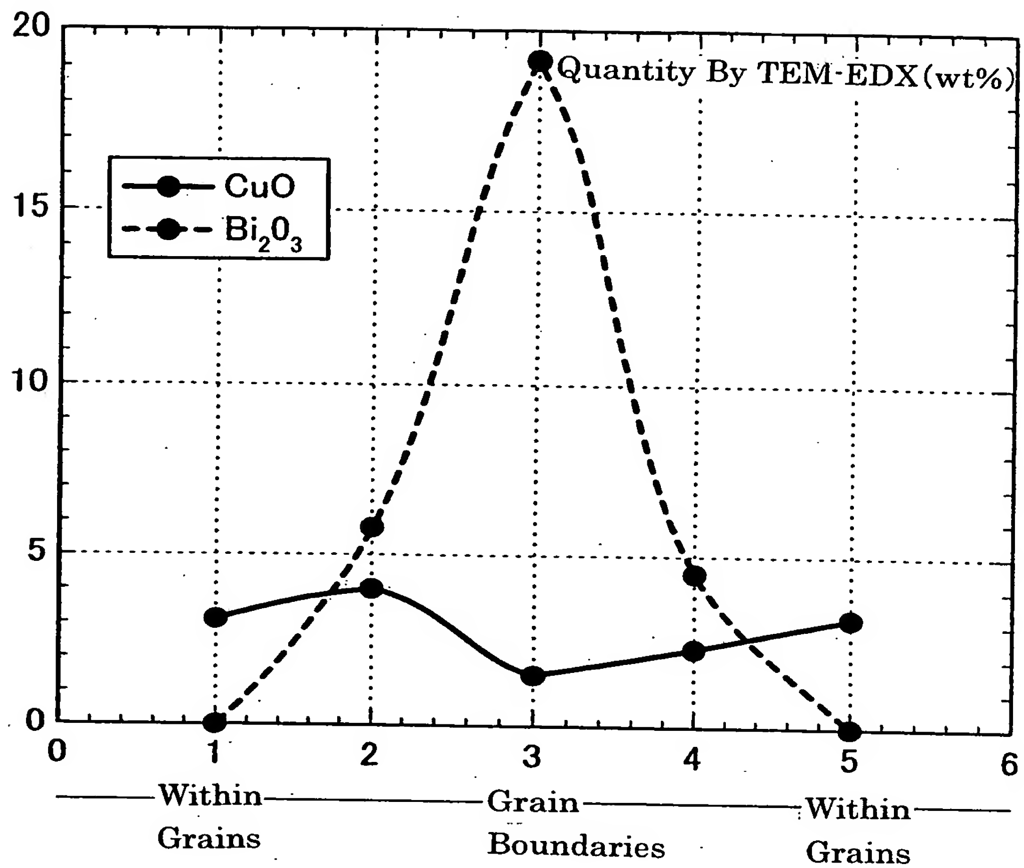

20
15
10
5
0
0
1
2
3
4
5
6
CuO
Bi_2O_3
Quantity By TEM-EDX(wt%)
Within Grains
Grain Boundaries
Within Grains

FIG. 7

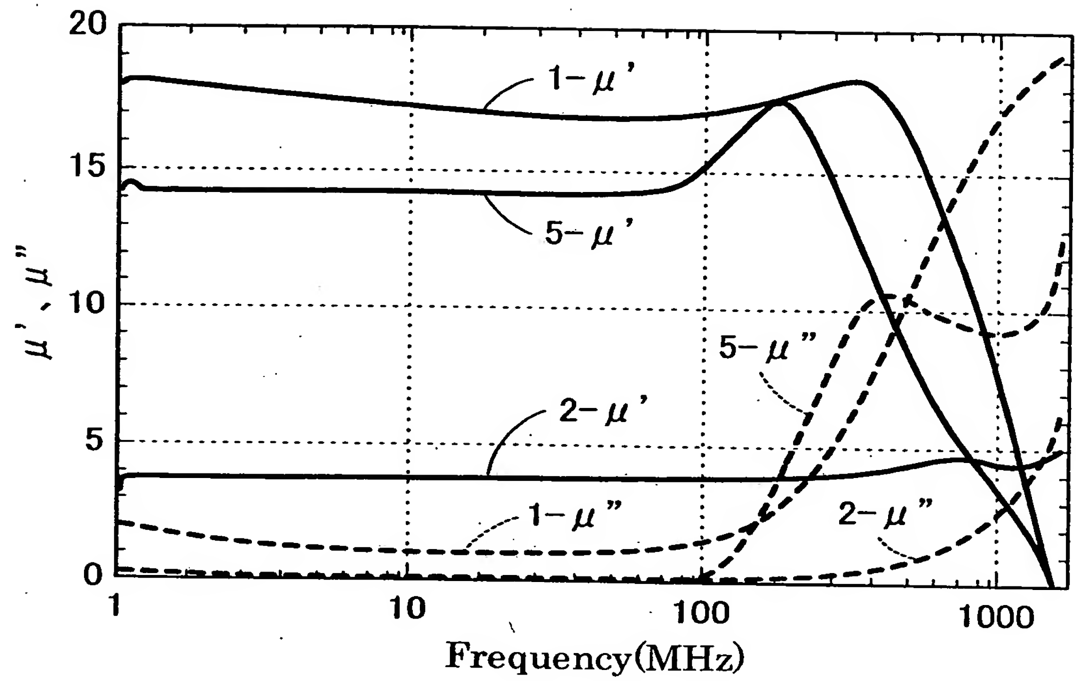


FIG. 8

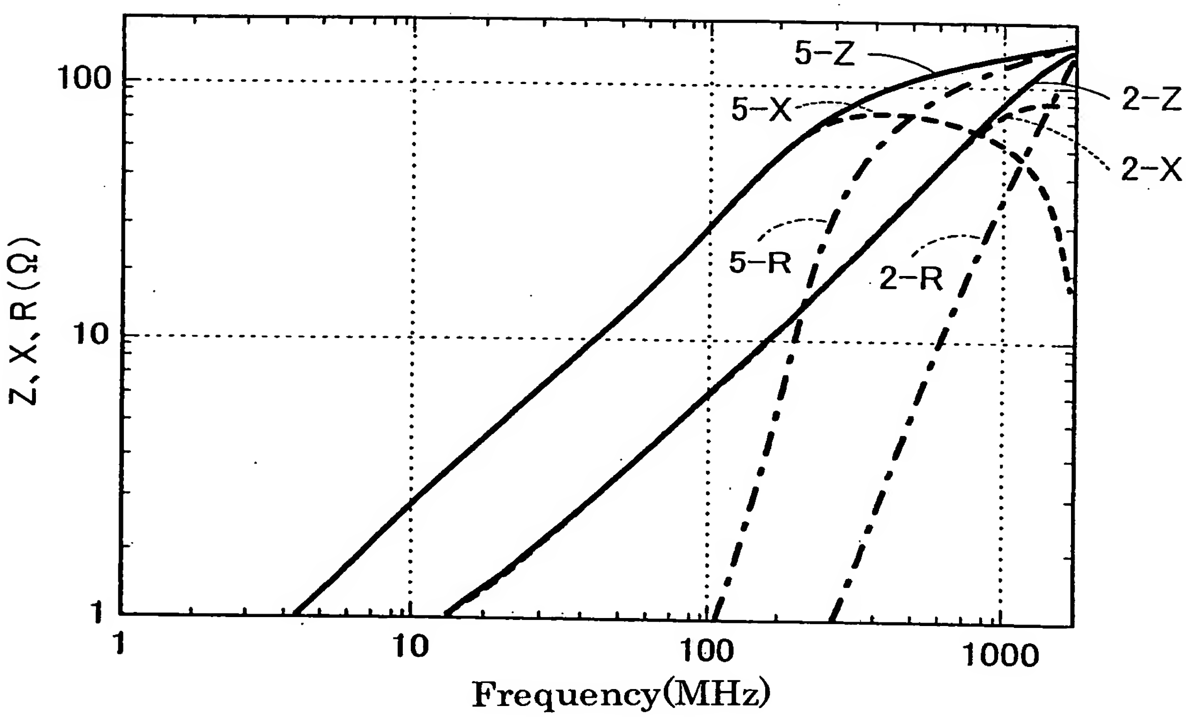


FIG. 9

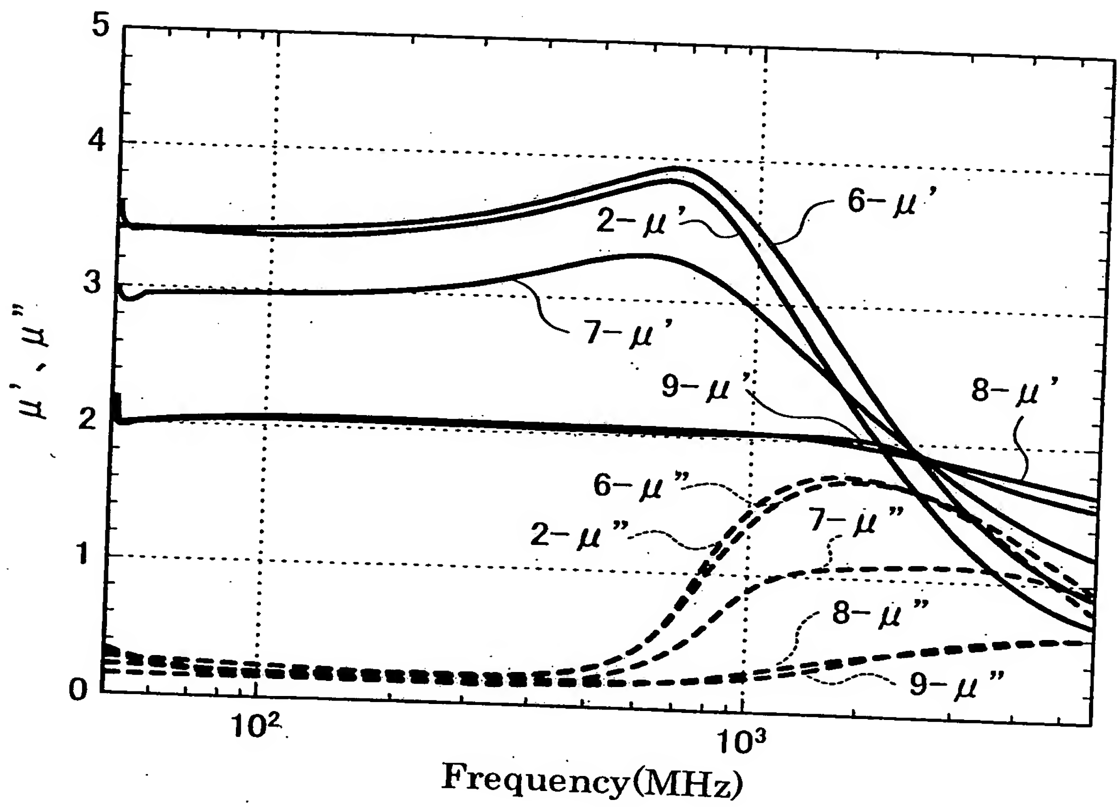


FIG. 10

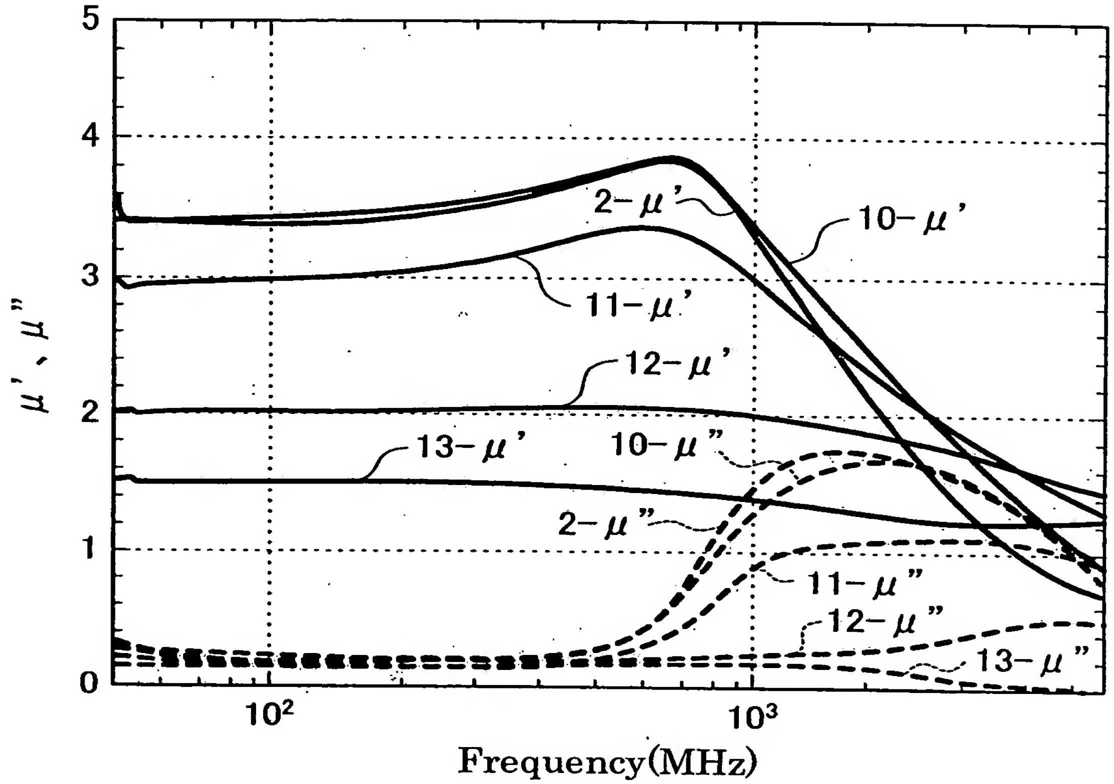
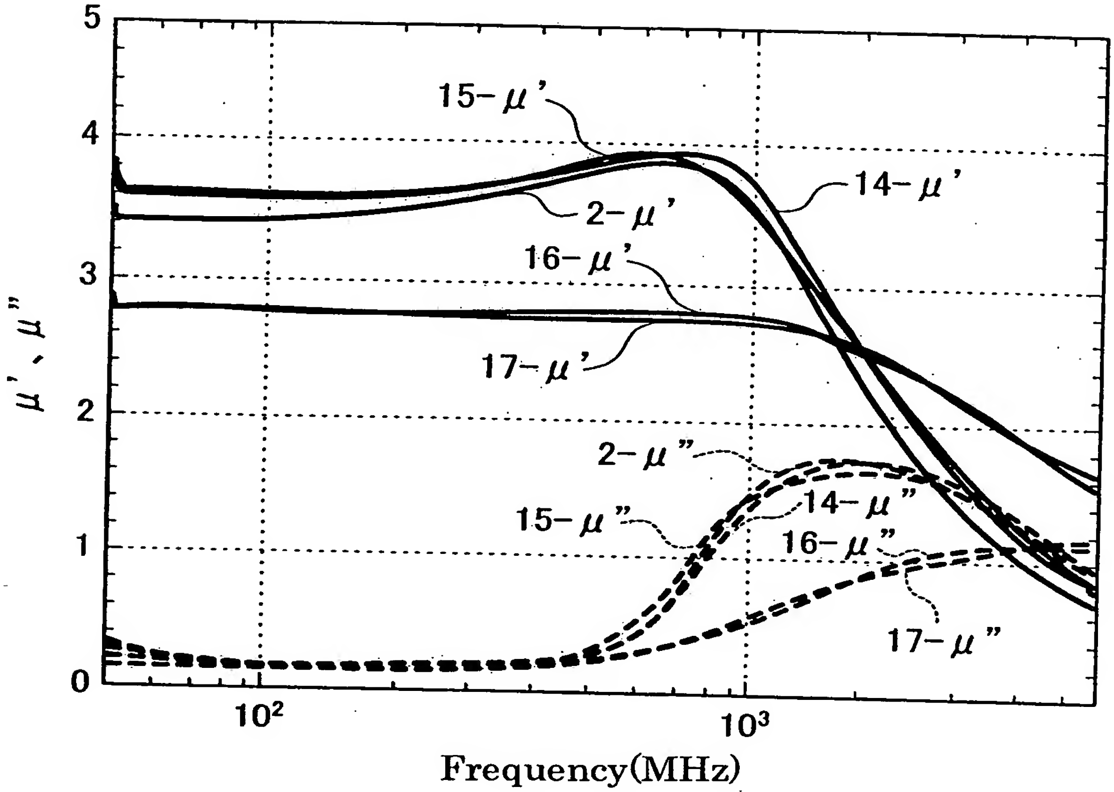

5
4
3
2
1
0
μ', μ"
10²
10³
Frequency(MHz)
2−μ'
10−μ'
11−μ'
12−μ'
13−μ'
10−μ"
2−μ"
11−μ"
12−μ"
13−μ"

FIG. 11



5
4
3
2
1
0
μ' 、μ"
15−μ'
14−μ'
2−μ'
16−μ'
17−μ'
2−μ"
14−μ"
15−μ"
16−μ"
17−μ"
10²
10³
Frequency(MHz)

FIG. 12

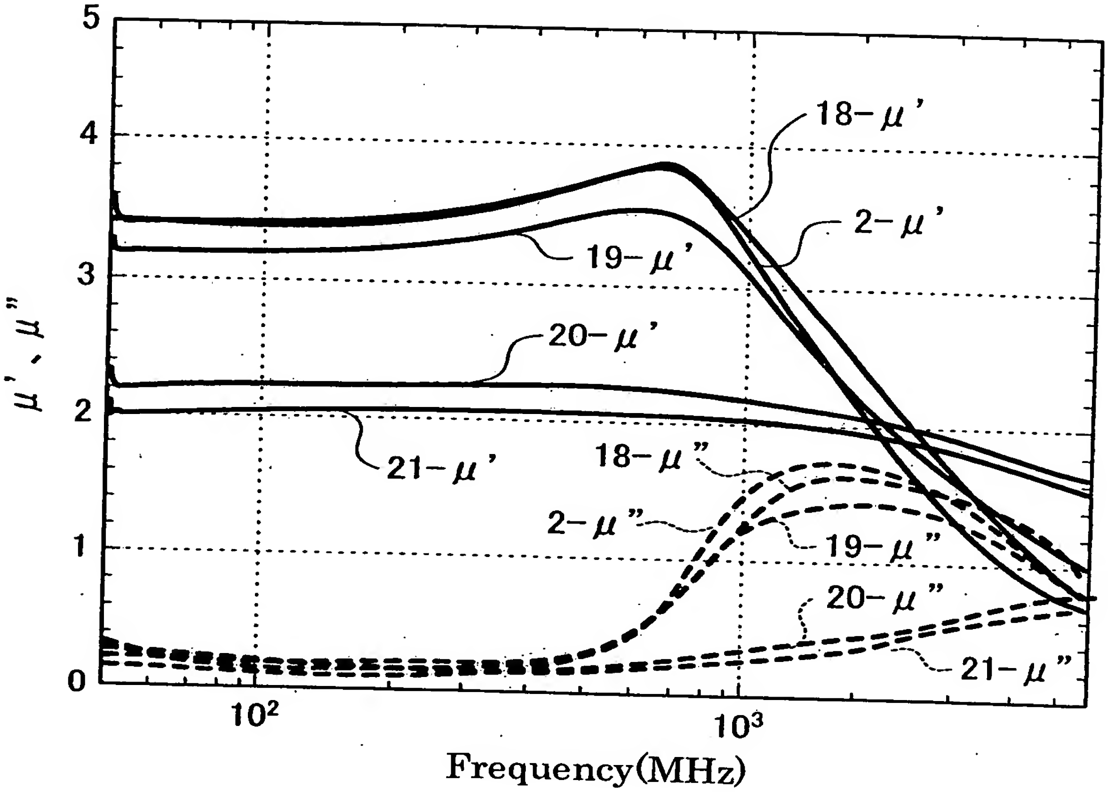

5
4
3
2
1
0
μ', μ"
18−μ'
2−μ'
19−μ'
20−μ'
21−μ'
18−μ"
2−μ"
19−μ"
20−μ"
21−μ"
10^2
10^3
Frequency(MHz)

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FIG. 13

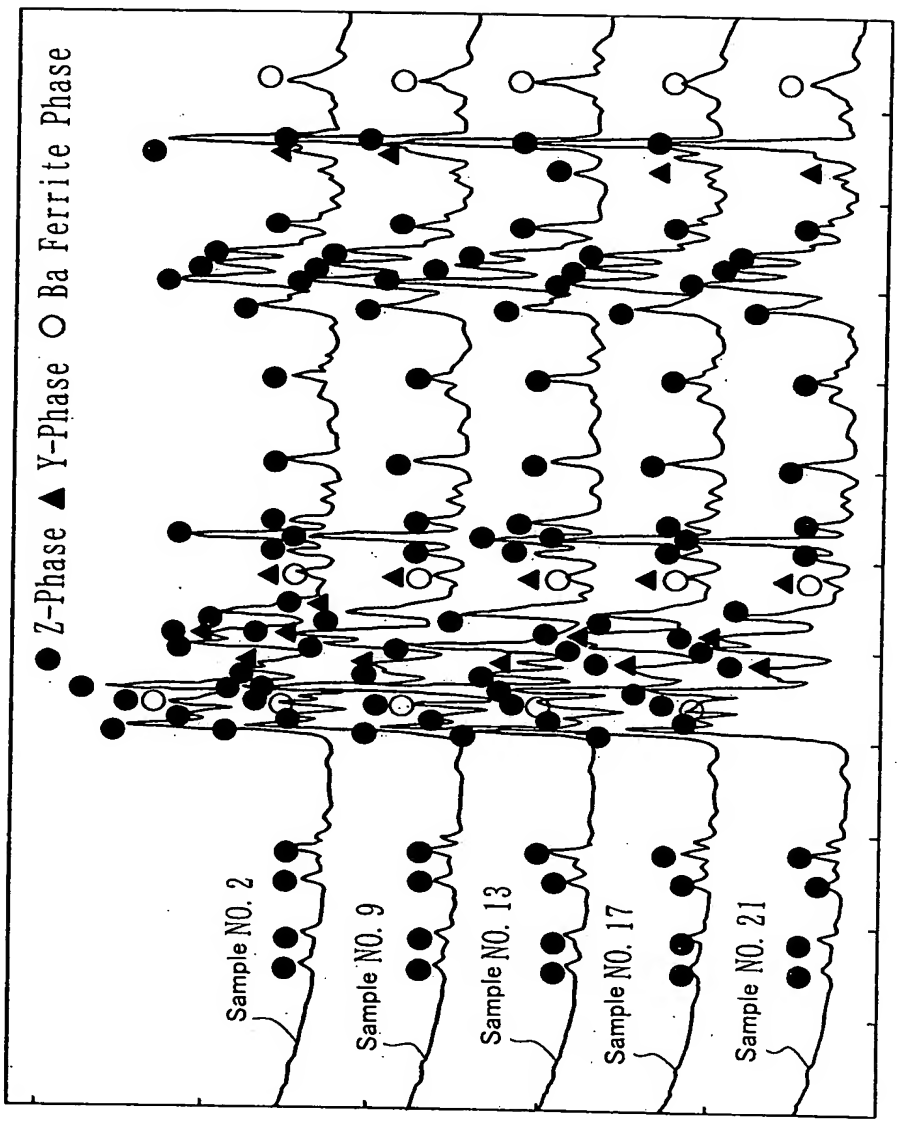
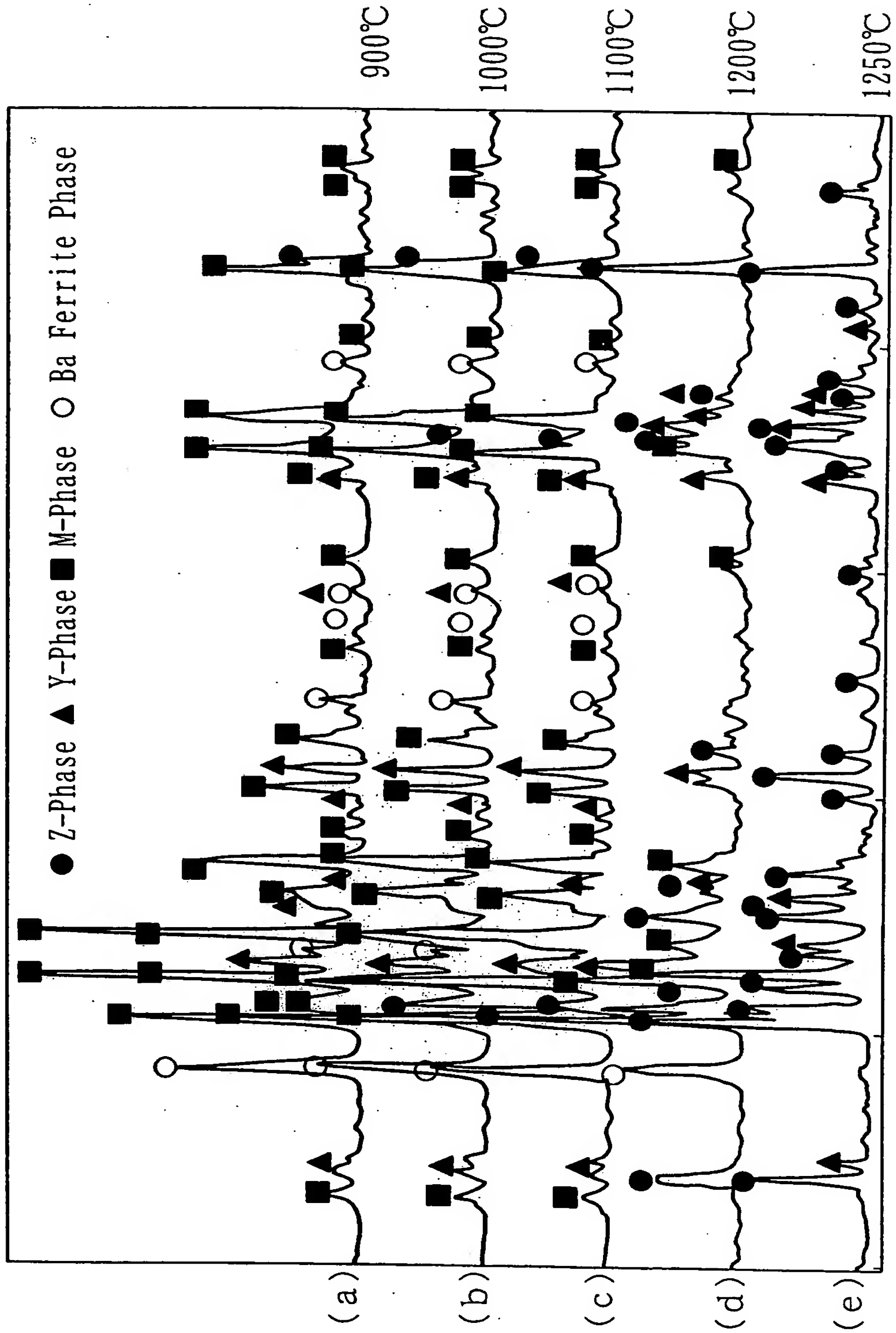


FIG. 14



● Z-Phase ▲ Y-Phase ■ M-Phase ○ Ba Ferrite Phase
900℃
1000℃
1100℃
1200℃
1250℃
(a)
(b)
(c)
(d)
(e)

FIG. 15

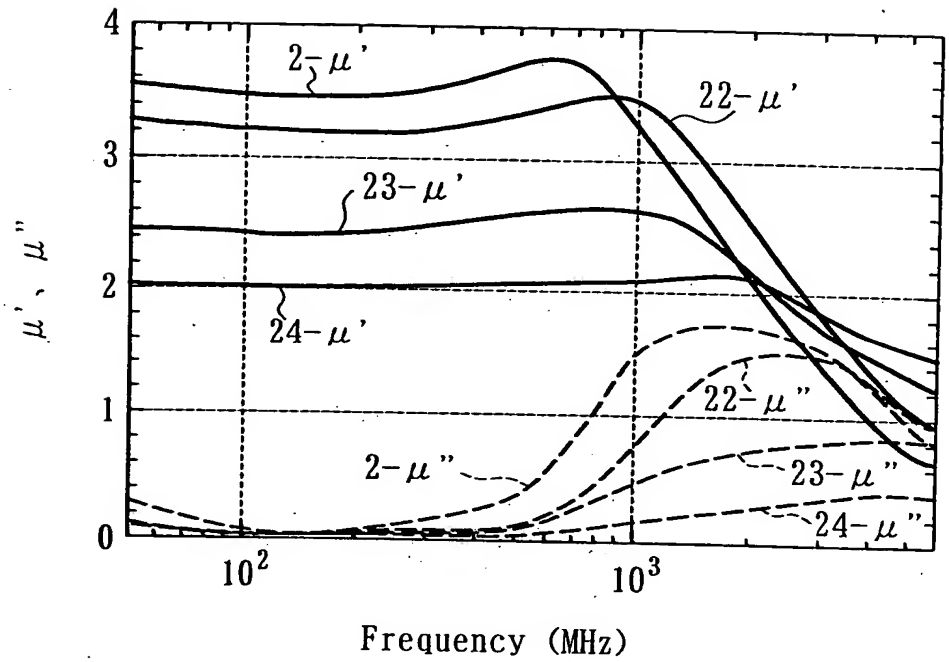


FIG. 16

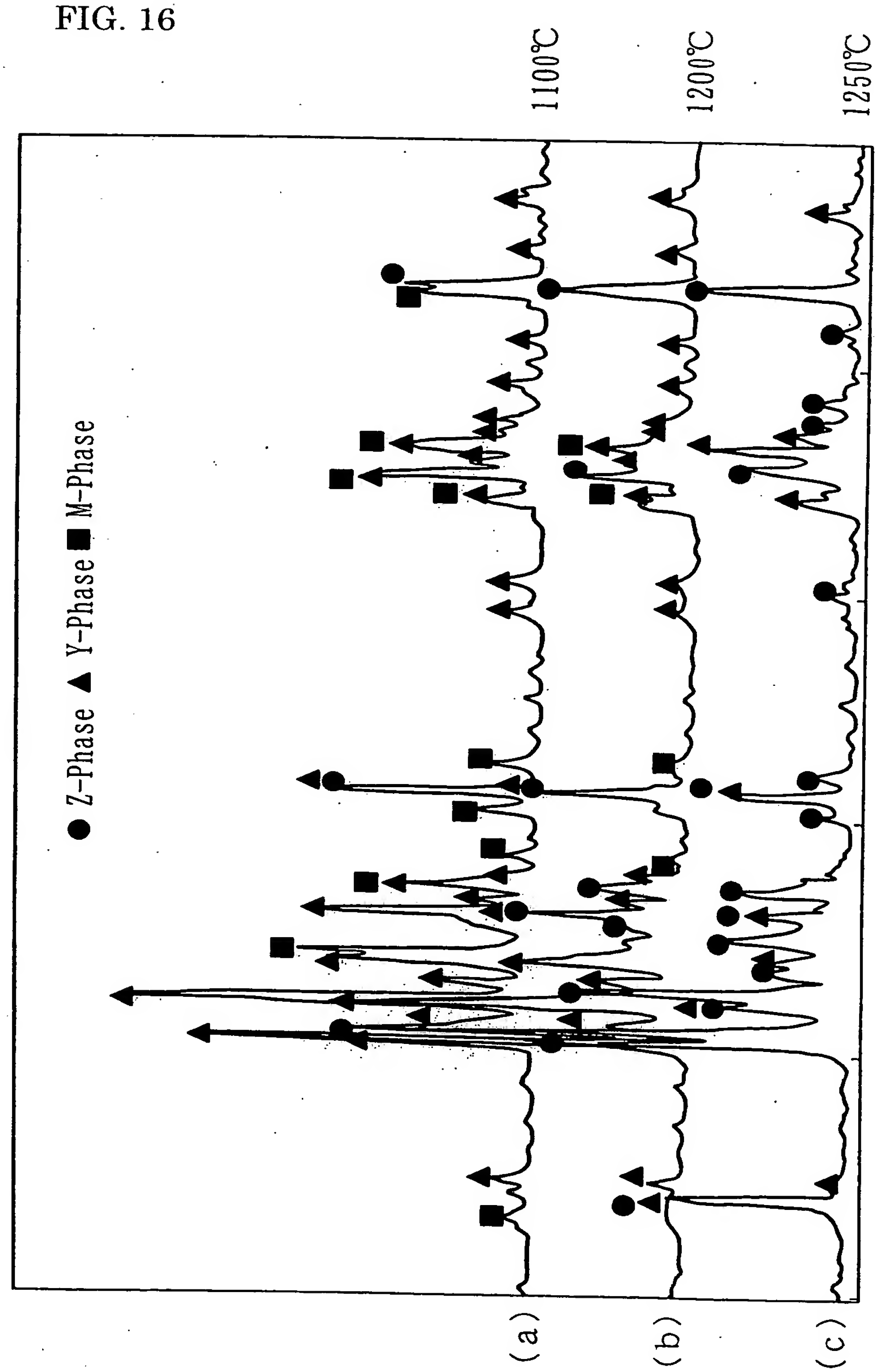


FIG. 17

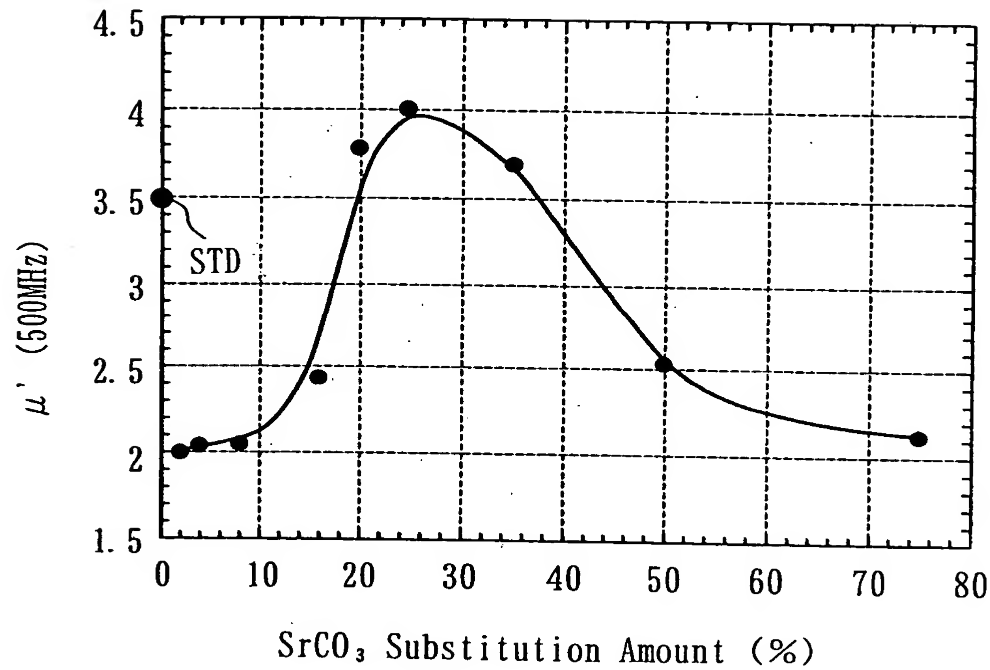

4.5
4
3.5
3
2.5
2
1.5
STD
μ' (500MHz)
0
10
20
30
40
50
60
70
80
SrCO₃ Substitution Amount (%)

FIG. 18

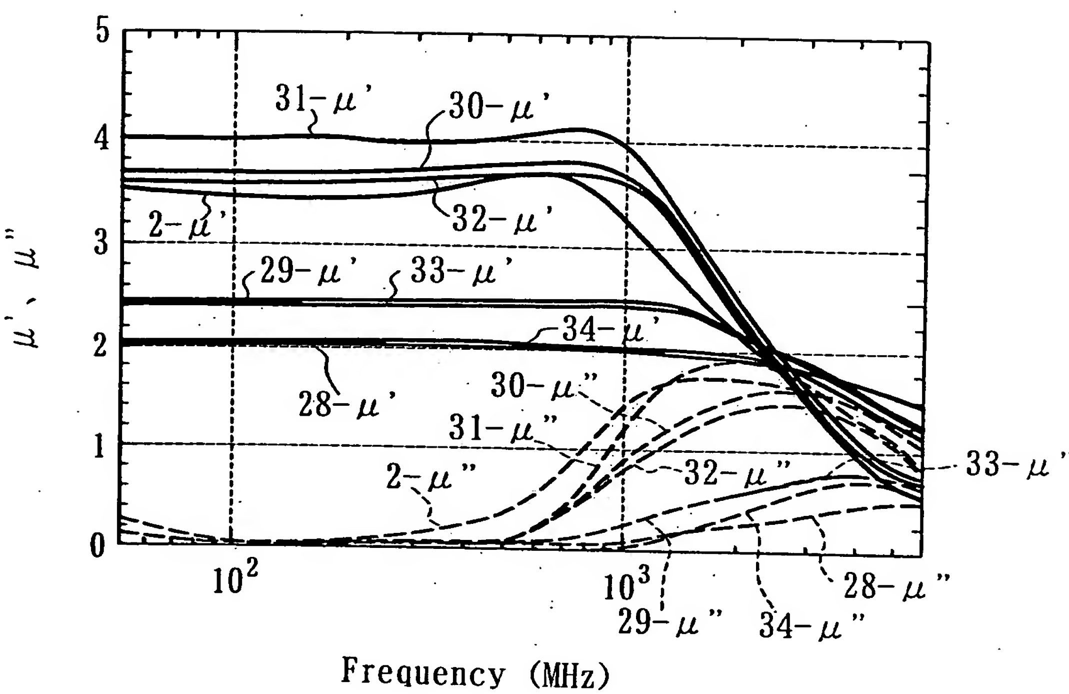

5
4
3
2
1
0
μ', μ"
31-μ'
30-μ'
32-μ'
2-μ'
29-μ'
33-μ'
34-μ'
28-μ'
30-μ"
31-μ"
2-μ"
32-μ"
33-μ"
28-μ"
29-μ"
34-μ"
10^2
10^3
Frequency (MHz)

FIG. 19

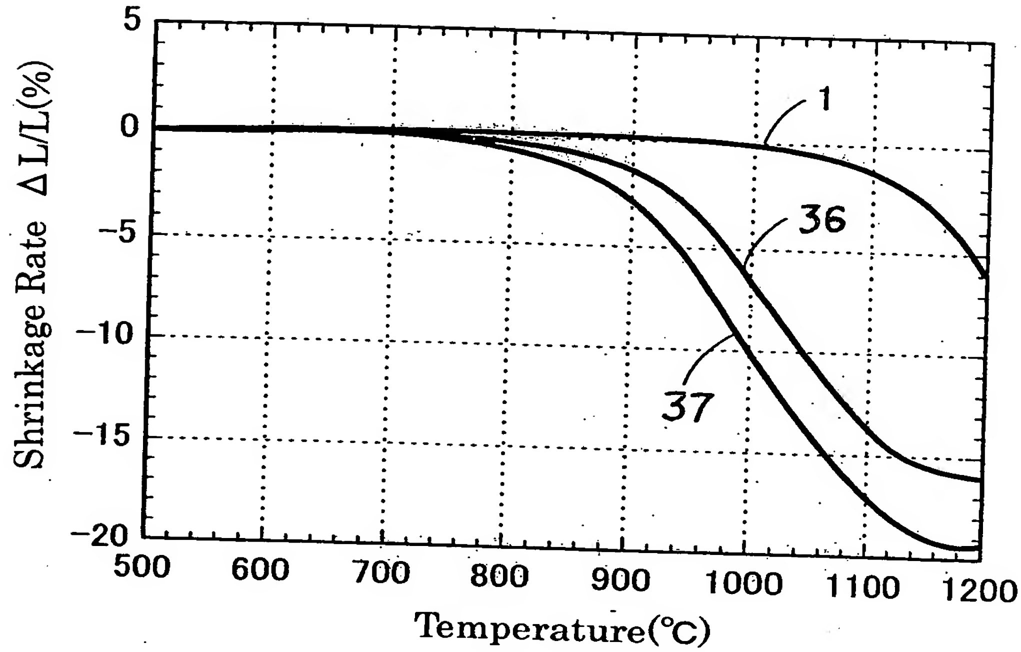

Shrinkage Rate ΔL/L(%)
5
0
−5
−10
−15
−20
500
600
700
800
900
1000
1100
1200
Temperature(℃)
1
36
37

FIG. 20

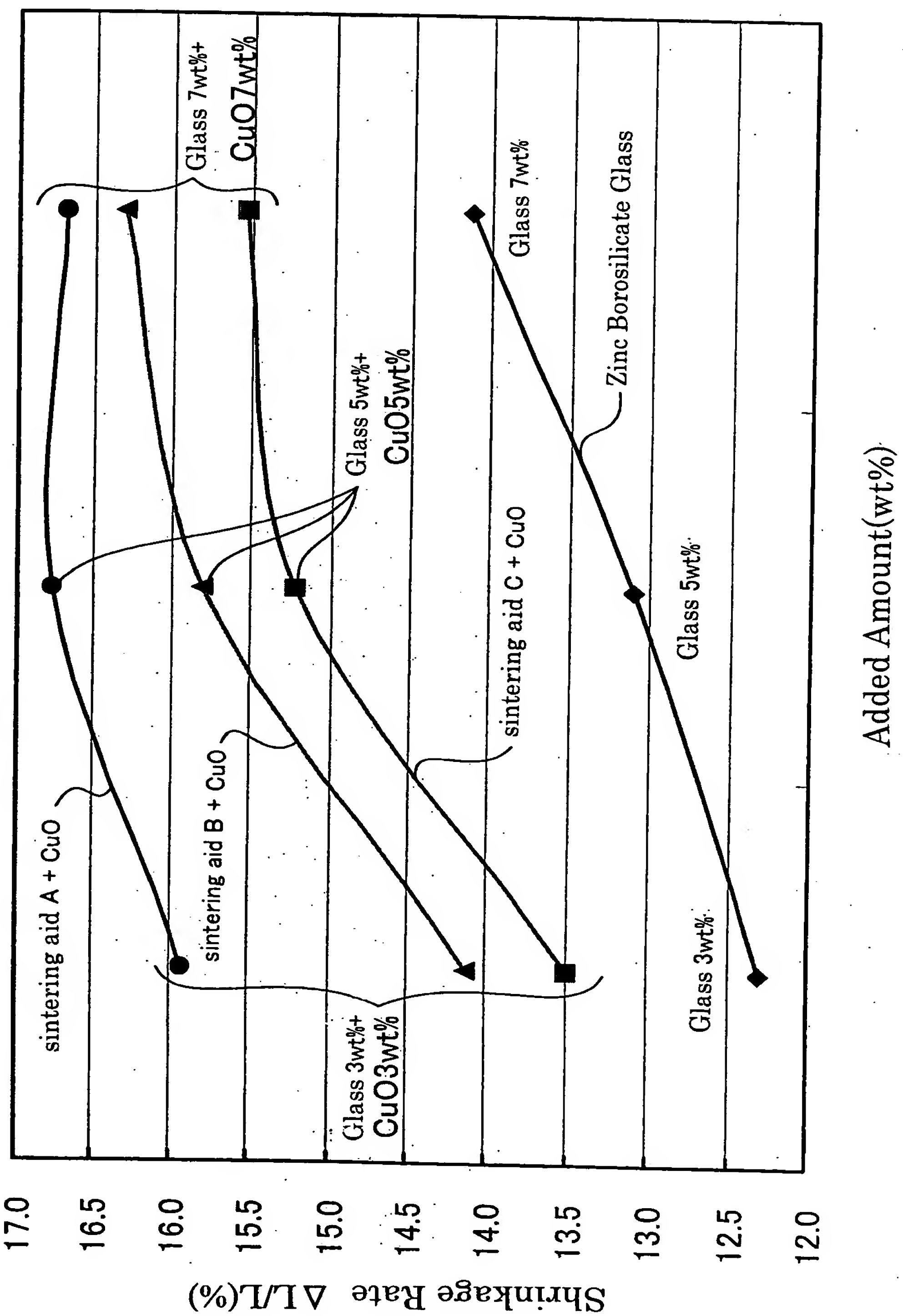
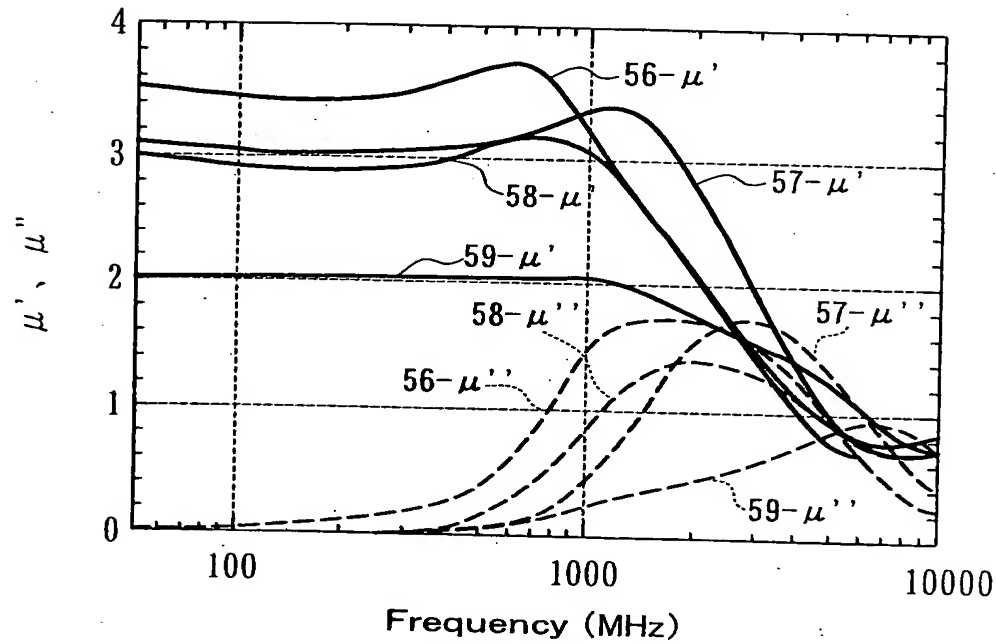
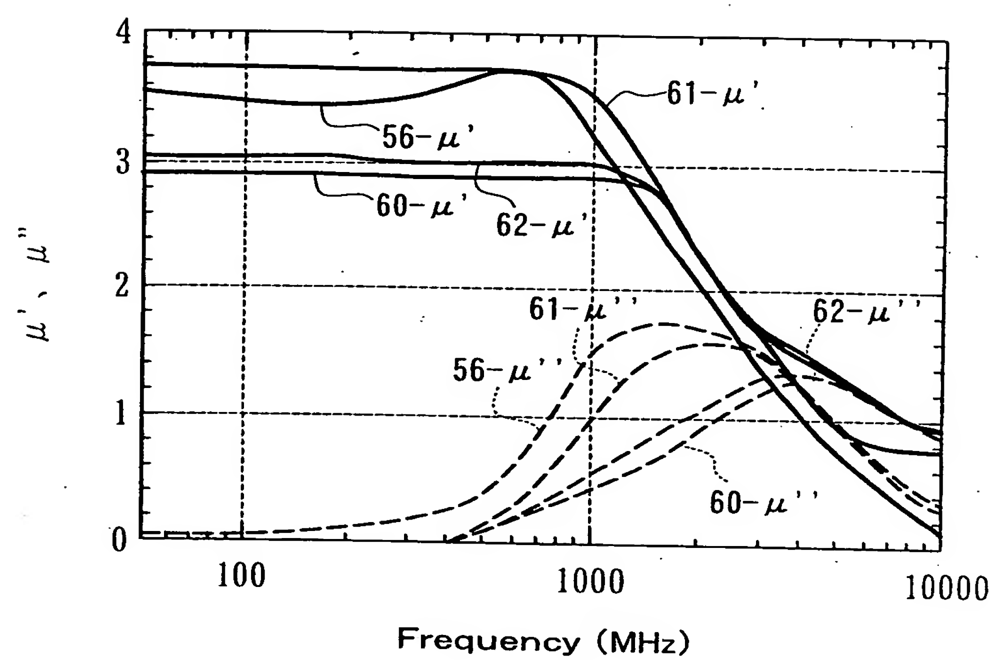

Glass 7wt%+
CuO7wt%
Glass 5wt%+
CuO5wt%
Glass 3wt%+
CuO3wt%
sintering aid A + CuO
sintering aid B + CuO
sintering aid C + CuO
Glass 7wt%
Zinc Borosilicate Glass
Glass 5wt%
Glass 3wt%
Added Amount(wt%)
Shrinkage Rate ΔL/L(%)
17.0
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0

FIG. 21



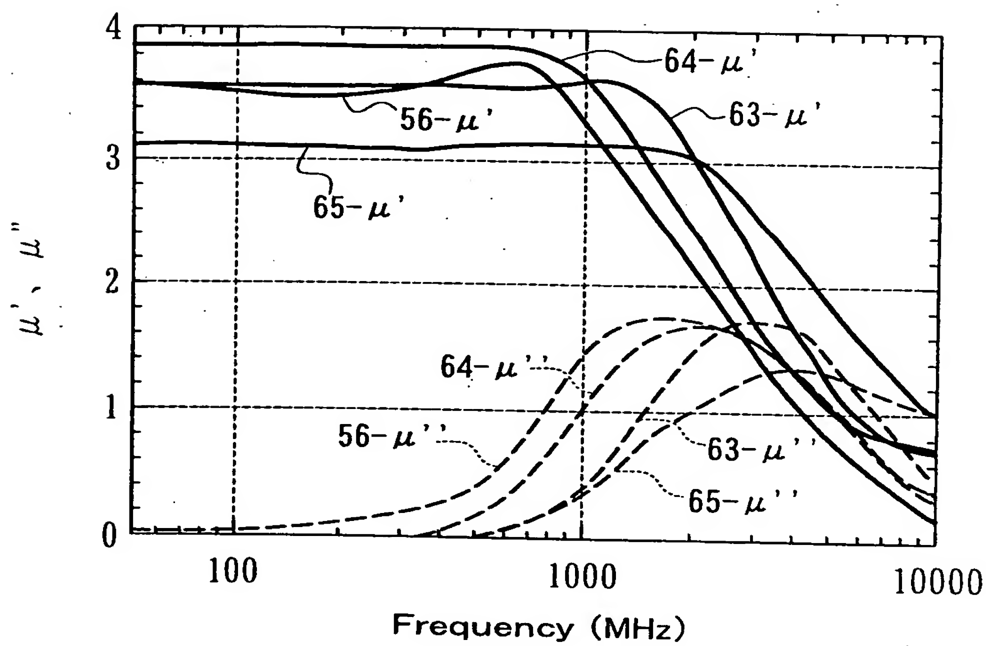
56-μ'
57-μ'
58-μ'
59-μ'
58-μ''
57-μ''
56-μ''
59-μ''
μ', μ''
4
3
2
1
0
100
1000
10000
Frequency (MHz)

FIG. 22



4
3
2
1
0
100
1000
10000
Frequency (MHz)
μ' 、 μ"
61-μ'
56-μ'
60-μ'
62-μ'
61-μ''
62-μ''
56-μ''
60-μ''

FIG. 23



64-μ'
63-μ'
56-μ'
65-μ'
64-μ''
56-μ''
63-μ''
65-μ''
μ', μ''
4
3
2
1
0
100
1000
10000
Frequency (MHz)

FIG. 24

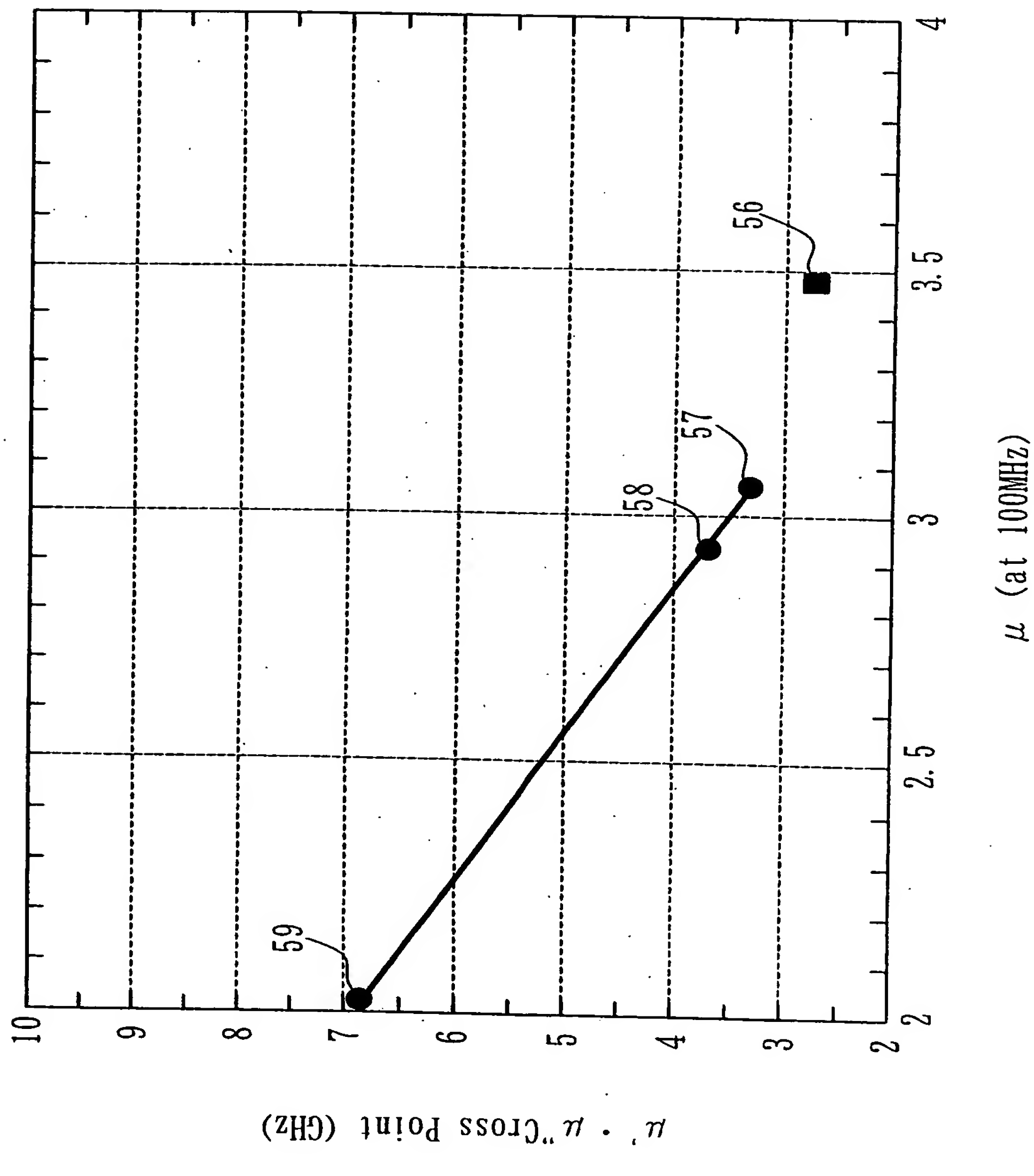


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FIG. 25

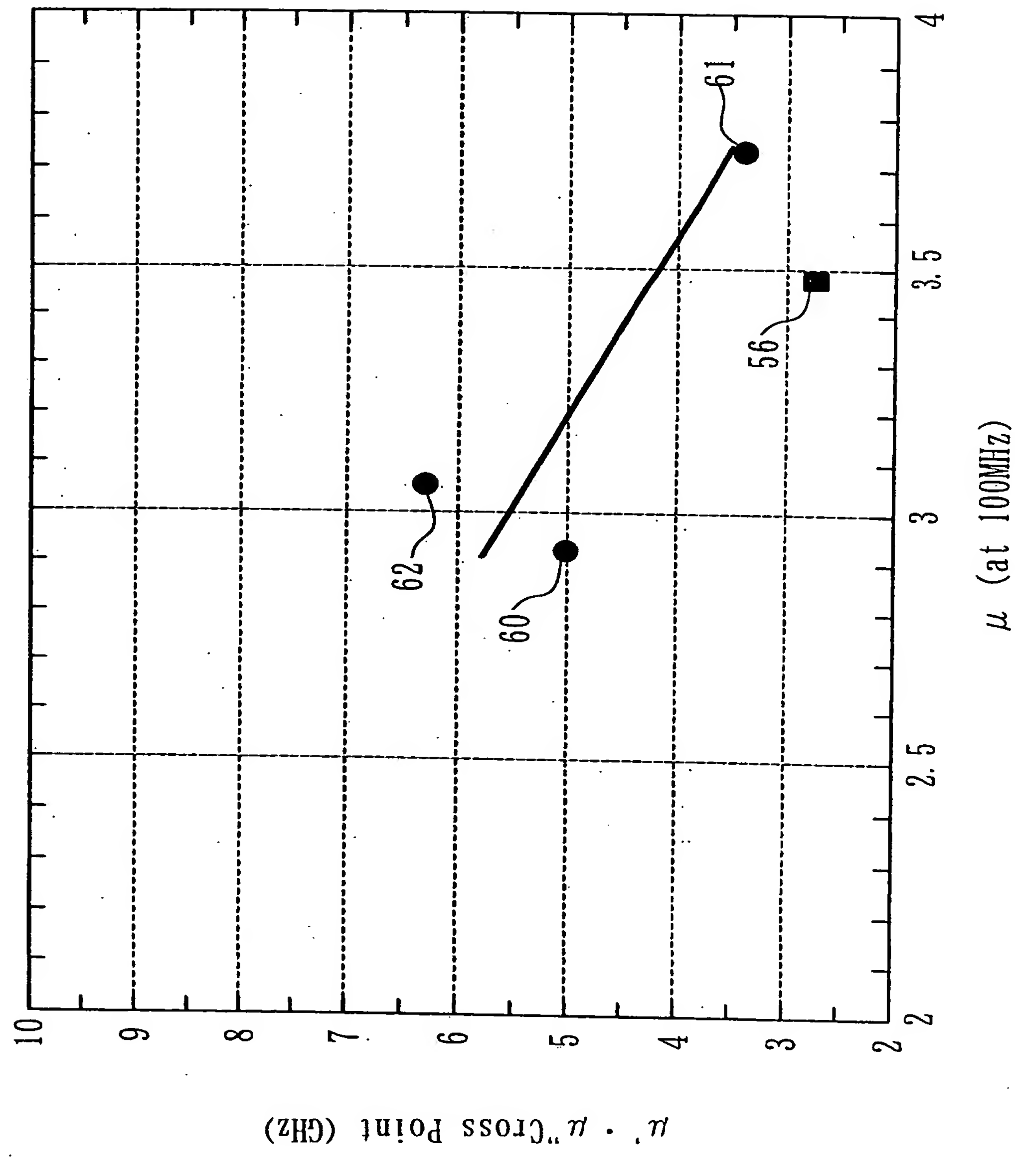


FIG. 26

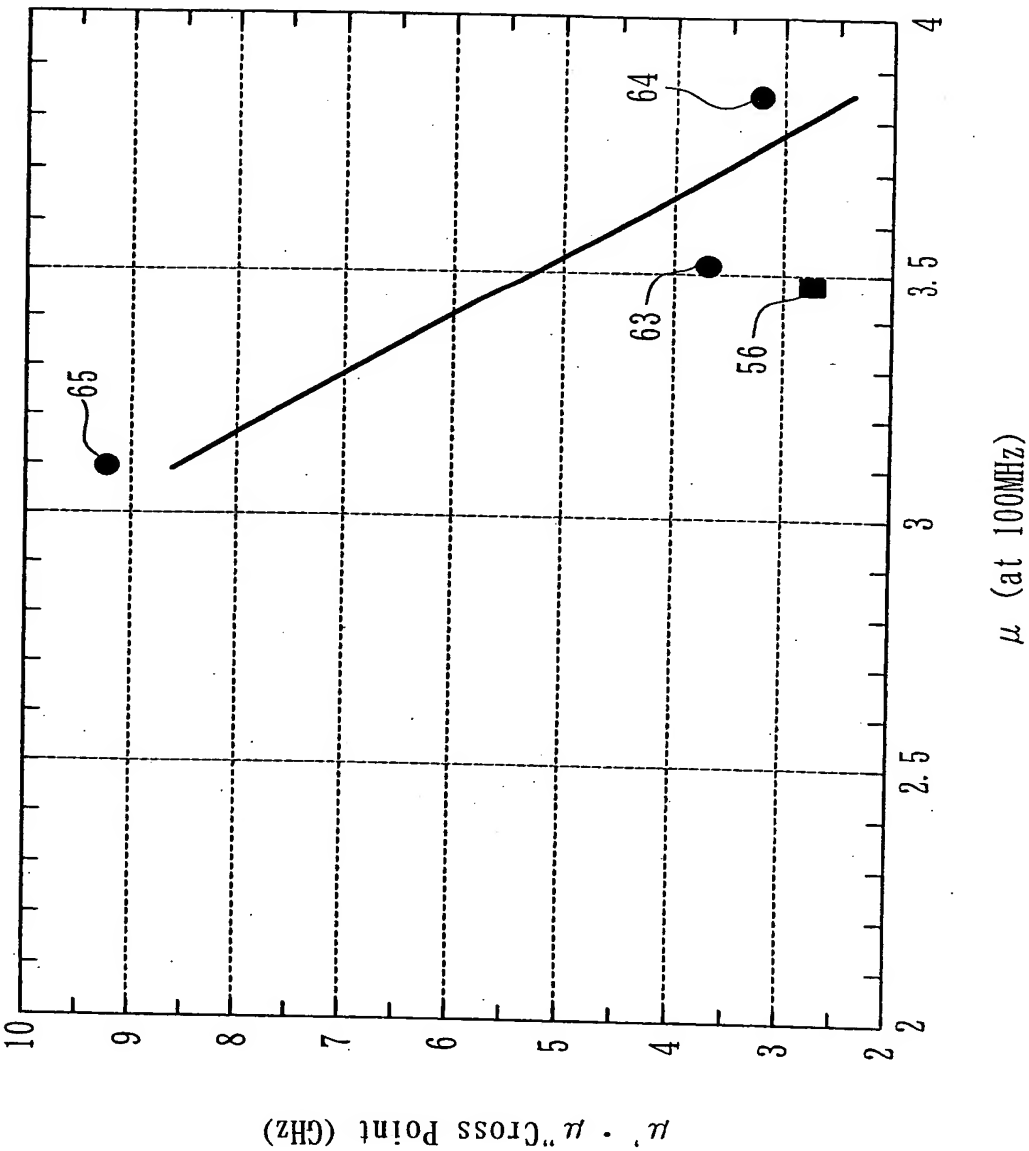


FIG. 27

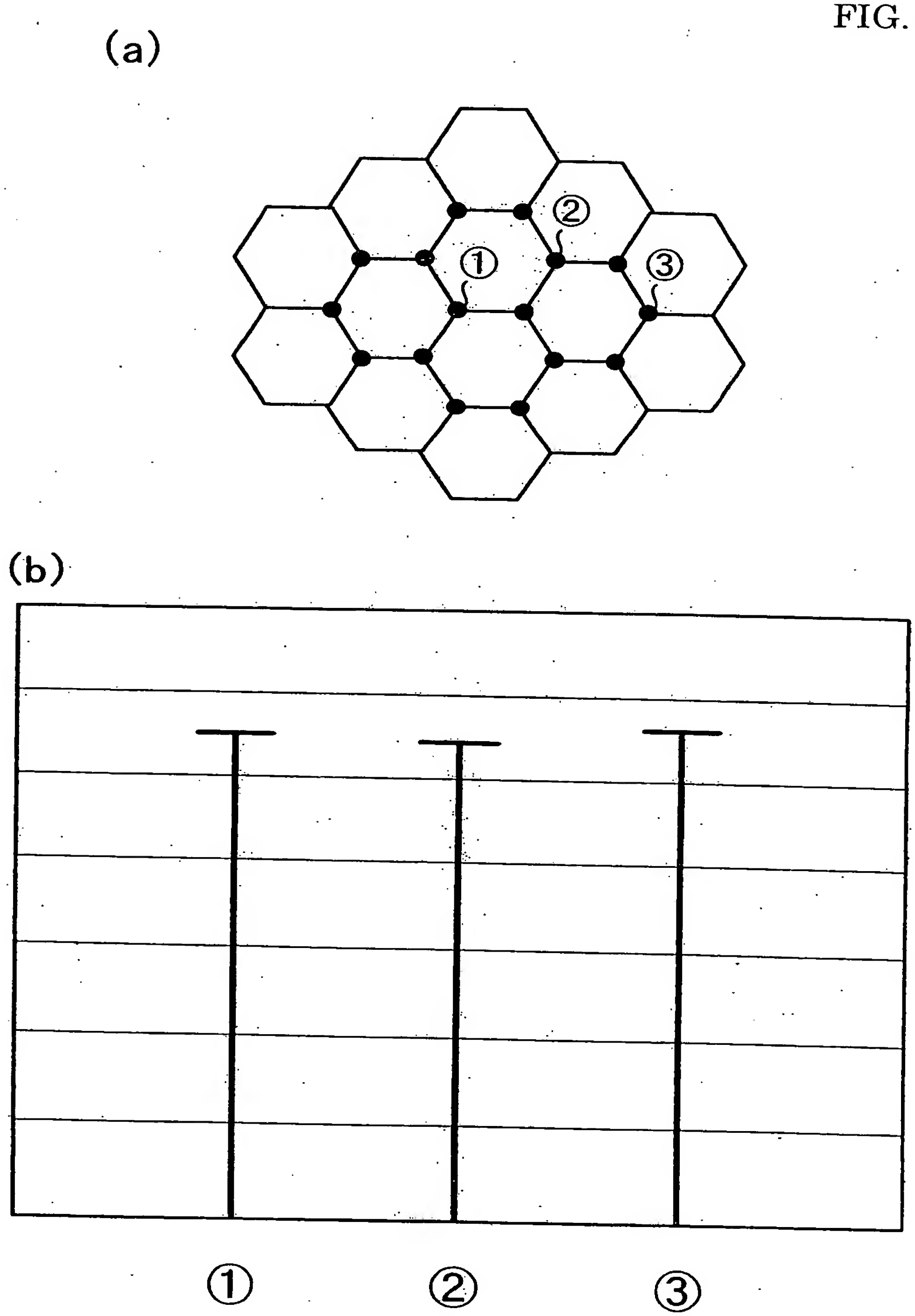
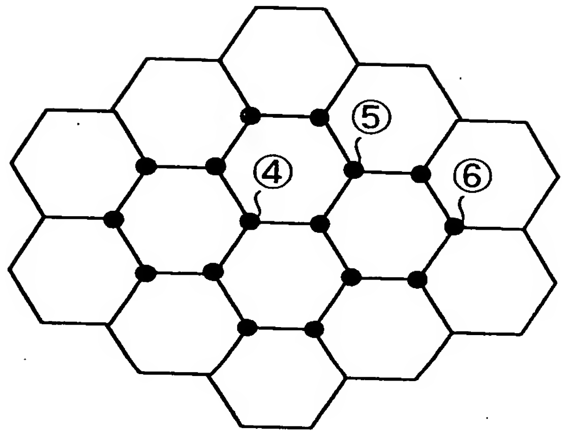


FIG. 28

(a)



(b)

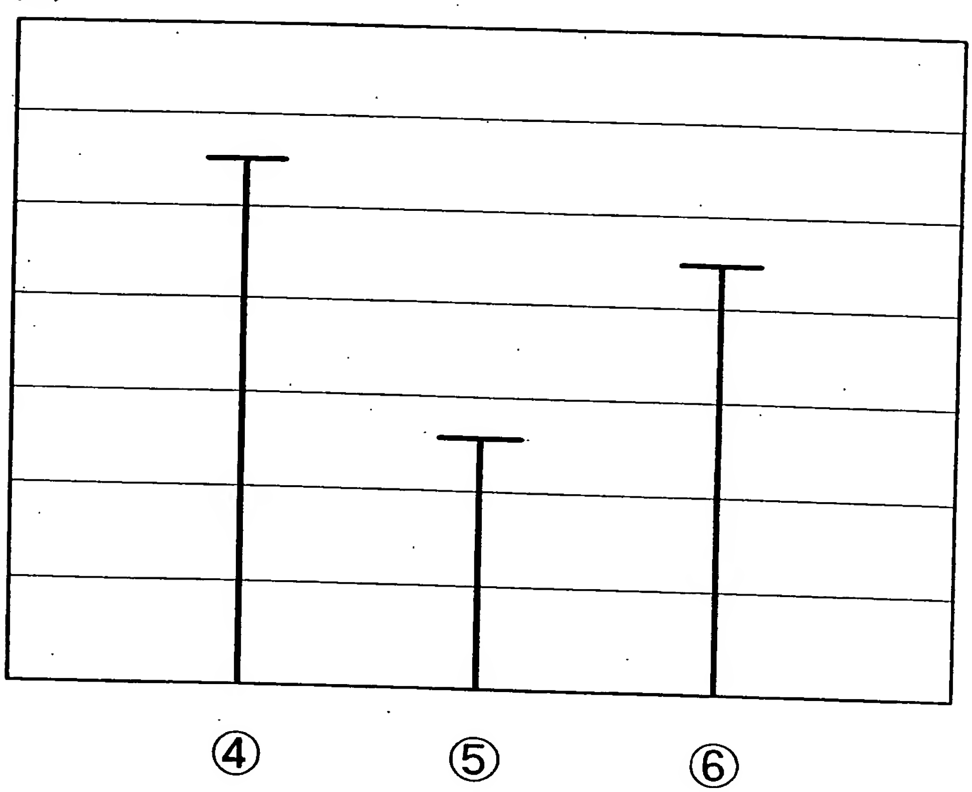


FIG. 29

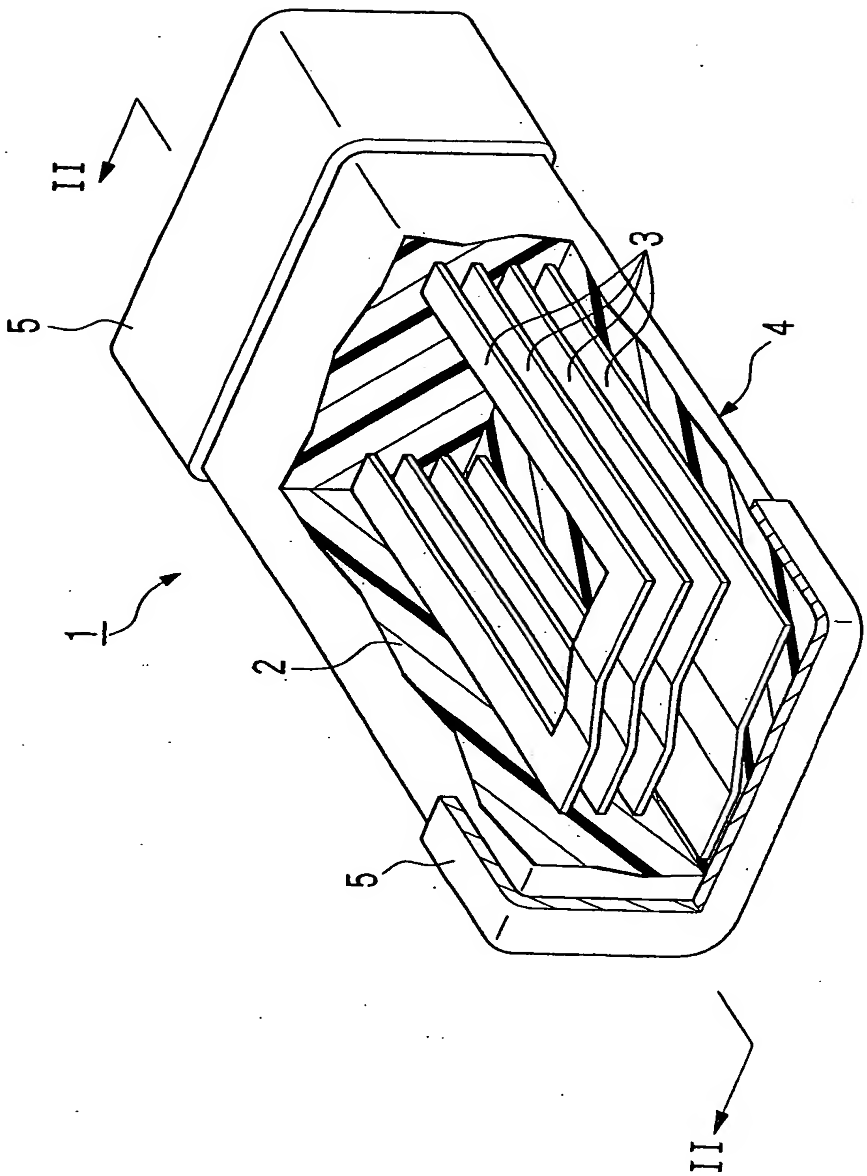
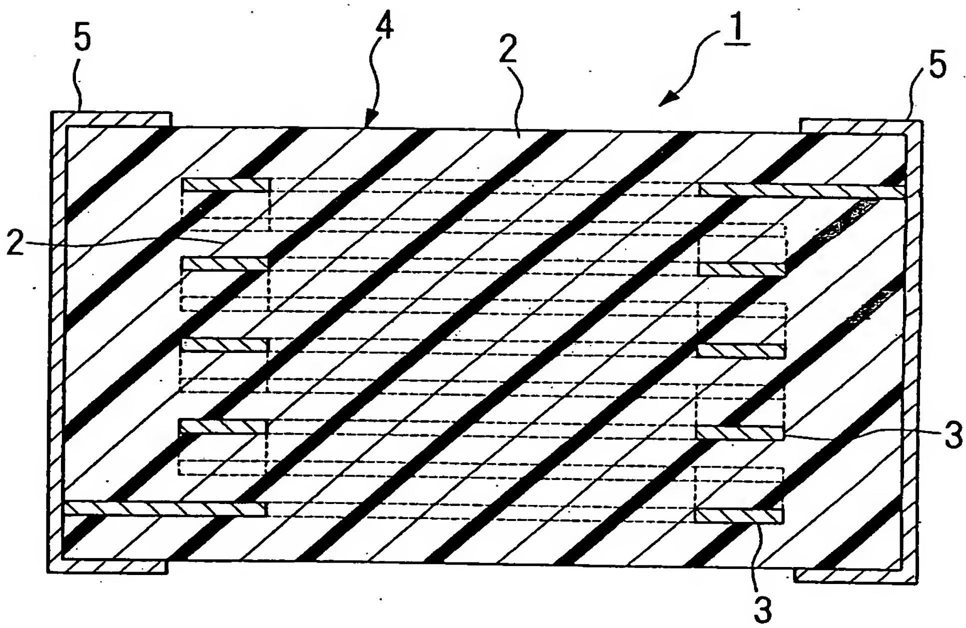


FIG. 30



10/009075

FIG. 31

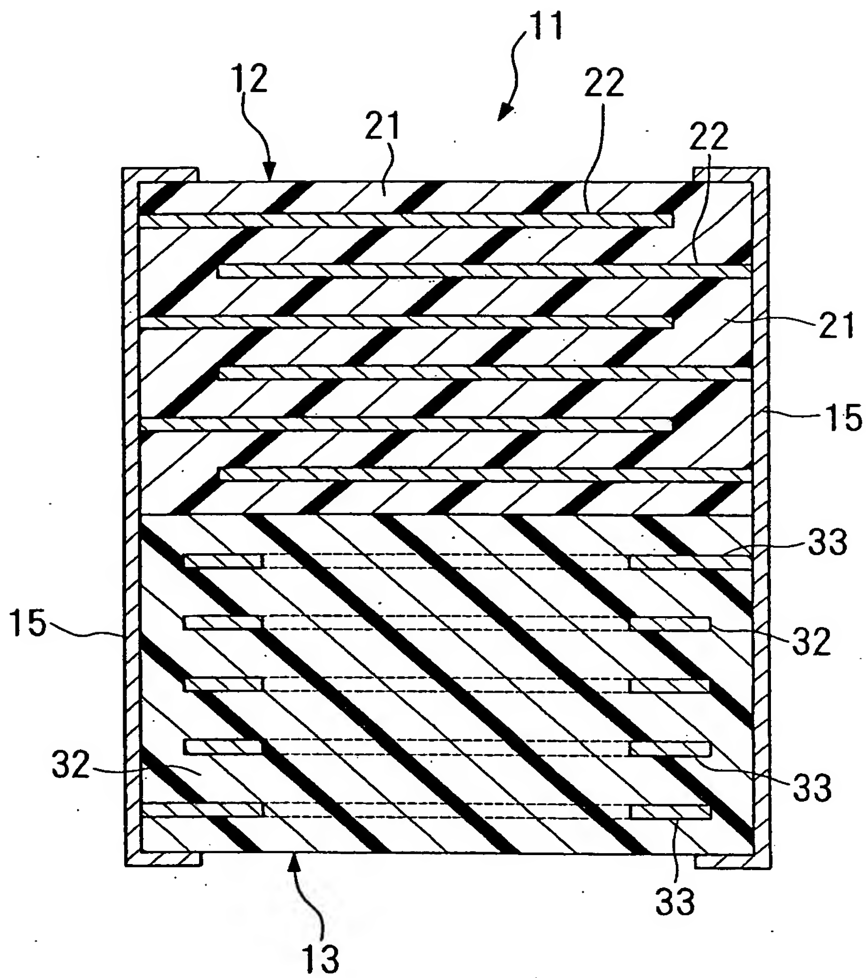


FIG.32

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	CuO (wt%)	Bi_2O_3 (wt%)	P ak Valu Of Grain Size Distribution	Note
1	68.7	21.035	10.265	—	—	—	Hexagonal Ferrite
2	68.7	21.035	10.265	5.00	5.00	1.0 μm	Hexagonal Ferrite
3	68.7	21.035	10.265	5.00	5.00	1.65 μm	Hexagonal Ferrite
4	68.7	21.035	10.265	5.00	5.00	3.3 μm	Hexagonal Ferrite

FIG.33

Sample No.	Fe_2O_3 (mol%)	NiO (mol%)	CuO (mol%)	ZnO (mol%)	CoO (wt%)	Note
5	48.6	44.9	5.10	1.4	0.2	NiCuZn Ferrite

FIG.34

(m^2/g)

Raw Material Powder	Specific Surface Area
Fe_2O_3	5.5
$BaCO_3$	10.6
Co_3O_4	12
CuO	6.7
NiO	5
MnO	19
ZnO	5.2
MgO	9.8

FIG.35

Specific Surface Area (m^2/g)	μ (100MHz)	Sintered Body Density (g/cm^3)	Shrinkage Rate (%)	Smoothness	Use As Paint	Note
1	2.5	4.5	14	×	○	Many Large Grains, Bad Sheet State Condition
5	3.8	4.9	17.3	○	○	
10	3.7	5.18	18.46	○	○	
15	3.7	5.22	18.5	○	○	
20	3.7	5.24	18.6	○	○	
25	3.7	5.25	18.58	○	○	
35	3.7	5.23	18.8	○	×	Paint Becomes Gel

FIG.36

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	NiO (mol%)	MnO (mol%)	ZnO (mol%)	MgO (mol%)	CuO (wt%)	Bi_2O_3 (wt%)	Note
6	68.7	21.035	10.162	0.103	–	–	–	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With NiO
7	68.7	21.035	9.752	0.513	–	–	–	5.00	5.00	
8	68.7	21.035	7.699	2.566	–	–	–	5.00	5.00	
9	68.7	21.035	5.133	5.133	–	–	–	5.00	5.00	
10	68.7	21.035	10.162	–	0.103	–	–	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With MnO
11	68.7	21.035	9.752	–	0.513	–	–	5.00	5.00	
12	68.7	21.035	7.699	–	2.566	–	–	5.00	5.00	
13	68.7	21.035	5.133	–	5.133	–	–	5.00	5.00	
14	68.7	21.035	10.162	–	–	0.103	–	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With ZnO
15	68.7	21.035	9.752	–	–	0.513	–	5.00	5.00	
16	68.7	21.035	7.699	–	–	2.566	–	5.00	5.00	
17	68.7	21.035	5.133	–	–	5.133	–	5.00	5.00	
18	68.7	21.035	10.162	–	–	–	0.103	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With MgO
19	68.7	21.035	9.752	–	–	–	0.513	5.00	5.00	
20	68.7	21.035	7.699	–	–	–	2.566	5.00	5.00	
21	68.7	21.035	5.133	–	–	–	5.133	5.00	5.00	

FIG.37

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	CuO (mol%)	Bi_2O_3 (wt%)	CuO (wt%)	Note
22	68.7	21.035	9.752	0.513	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With CuO By 5%
23	68.7	21.035	7.699	2.566	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With CuO By 25%
24	68.7	21.035	5.133	5.133	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With CuO By 50%
25	68.7	21.035	2.566	7.699	5.00	5.00	A Portion Of Co_3O_4 Was Substituted With CuO By 75%

FIG.38

Sample No.	Calcining Temprature (°C)	Sintered Body Density (g/cm^3)	Shrinkage Rate (%)	μ (500MHz)	ε (1MHz)
22	1200	5.06	15.46	1.77	40
	1250	5.24	17.96	3.61	38
23	1200	5.01	16.00	1.70	43
	1250	5.24	17.62	2.66	42
24	1200	5.10	16.35	1.80	43
	1250	5.23	17.73	2.03	43
25	1200	5.12	16.46	1.84	45
	1250	—	—	—	—

FIG.39

Sampl No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	$SrCO_3$ (mol%)	Bi_2O_3 (wt%)	CuO (wt%)	Note
26	68.7	20.614	10.162	0.421	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 2%
27	68.7	20.194	10.162	0.841	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 4%
28	68.7	19.352	10.162	1.683	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 8%
29	68.7	17.669	10.162	3.366	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 16%
30	68.7	16.828	10.162	4.207	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 20%
31	68.7	15.776	10.162	5.259	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 25%
32	68.7	13.673	10.162	7.362	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 35%
33	68.7	10.517	10.162	10.517	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 50%
34	68.7	5.259	10.162	15.776	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 75%
35	68.7	0	10.162	21.035	5.00	5.00	A Portion Of $BaCO_3$ Was Substituted With $SrCO_3$ By 100%

FIG.40

Sample No.	Calcining Temprature (℃)	Sintered Body Density (g/cm^3)	Shrinkage Rate (%)	μ' (500MHz)	μ'' (500MHz)
26	1300	5.23	17.04	2.00	0.034
27	1300	5.21	17.00	2.03	0.042
28	1300	5.17	17.00	2.05	0.051
29	1300	4.92	15.85	2.44	0.073
30	1250	4.83	15.38	3.80	0.137
31	1250	4.69	15.01	4.01	0.260
32	1250	3.76	9.74	3.70	0.190
33	1250	2.97	2.62	2.54	0.010
34	1250	2.99	0.85	2.12	0.010
35	1250	—	—	—	—

FIG.41

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	Glass A (wt%)	Glass B (wt%)	Note
36	68.7	21.04	10.27	—	5.00	Glass A: Zinc Borosilicate Glass
37	68.7	21.04	10.27	5.00	—	Glass B: Zinc Borosilicate Glass

FIG.42

(wt%)

	SiO_2	B_2O_3	ZnO	Al_2O_3	MnO	CoO	Li_2O	Na_2O	MgO	K_2O
Glass A	10.38	44.55	35.65	2.13	—	—	—	7.07	0.19	0.04
Glass B	17.4	10.4	51.5	—	3.50	4.2	13	—	—	—

FIG.43

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	Bi_2O_3 Based Glass (wt%)			Zinc Borosilicate Glass (wt%)	CuO (wt%)	Bi_2O_3 (wt%)
				Sintering Aid A	Sintering Aid B	Sintering Aid C			
38	68.7	21.035	10.265	3.00	—	—	—	—	—
39	68.7	21.035	10.265	5.00	—	—	—	—	—
40	68.7	21.035	10.265	7.00	—	—	—	—	—
41	68.7	21.035	10.265	9.00	—	—	—	—	—
42	68.7	21.035	10.265	—	3.00	—	—	—	—
43	68.7	21.035	10.265	—	5.00	—	—	—	—
44	68.7	21.035	10.265	—	7.00	—	—	—	—
45	68.7	21.035	10.265	—	—	3.00	—	—	—
46	68.7	21.035	10.265	—	—	5.00	—	—	—
47	68.7	21.035	10.265	—	—	7.00	—	—	—
48	68.7	21.035	10.265	—	—	—	3.00	—	—
49	68.7	21.035	10.265	—	—	—	5.00	—	—
50	68.7	21.035	10.265	—	—	—	7.00	—	—
51	68.7	21.035	10.265	—	—	—	—	3.00	—
52	68.7	21.035	10.265	—	—	—	—	5.00	—
53	68.7	21.035	10.265	—	—	—	—	7.00	—
54	68.7	21.035	10.265	—	—	—	—	—	5.00
55	68.7	21.035	10.265	—	—	—	—	—	10.00
56	68.7	21.035	10.265	—	—	—	—	5.00	5.00

FIG.44

(wt%)

		Bi_2O_3	B_2O_3	ZnO	SiO_2	Al_2O_3	Na_2O	MgO	K_2O
Bi_2O_3 Based Glass	Sintering Aid A	83.83	13.75	—	1.94	—	—	—	—
	Sintering Aid B	49.51	19.68	27.51	2.4	0.12	—	—	—
	Sintering Aid C	39.89	19.57	37.3	2.32	0.16	—	—	—
Zinc Borosilicate Glass		—	44.55	35.65	10.38	2.13	7.07	0.19	0.04

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FIG.45

Sample No.	Shrinkage Rate (%)	Sintered Body Density (g/cm^3)	Additive					Calcining Temperature (°C)	Sintering Temperature (°C)
			Bi_2O_3 Based Glass			Zinc Borosilicate Glass	CuO		
			Sintering Aid A	Sintering Aid B	Sintering Aid C				
38	14.77	4.50	3wt%	—	—	—	—	1300	930
39	15.96	4.74	5wt%	—	—	—	—	1300	930
40	16.42	4.84	7wt%	—	—	—	—	1300	930
41	16.50	4.88	9wt%	—	—	—	—	1300	930
42	11.89	4.22	—	3wt%	—	—	—	1300	930
43	13.39	4.42	—	5wt%	—	—	—	1300	930
44	14.04	4.53	—	7wt%	—	—	—	1300	930
45	11.15	4.18	—	—	3wt%	—	—	1300	930
46	12.66	4.37	—	—	5wt%	—	—	1300	930
47	13.38	4.39	—	—	7wt%	—	—	1300	930
48	12.30	4.49	—	—	—	3wt%	—	1300	950
49	13.10	4.40	—	—	—	5wt%	—	1300	950
50	14.12	4.35	—	—	—	7wt%	—	1300	950

FIG.46

Sample No.	Relative Resistivity (MΩ·cm)	Bi_2O_3 Based Glass (wt%)			CuO (wt%)	Bi_2O_3 (wt%)
		Sintering Aid A	Sintering Aid B	Sintering Aid C		
38	360	3.00	—	—	—	—
39	770	5.00	—	—	—	—
40	940	7.00	—	—	—	—
41	840	9.00	—	—	—	—
42	75	—	3.00	—	—	—
43	310	—	5.00	—	—	—
44	910	—	7.00	—	—	—
45	51	—	—	3.00	—	—
46	140	—	—	5.00	—	—
47	310	—	—	7.00	—	—
51	51	—	—	—	3.00	—
52	37	—	—	—	5.00	—
53	18	—	—	—	7.00	—
54	21	—	—	—	—	5.00
55	18	—	—	—	—	10.00
56	24	—	—	—	5.00	5.00

FIG.47

Sample No.	Fe_2O_3 (mol%)	$BaCO_3$ (mol%)	Co_3O_4 (mol%)	Additive			Note
				Bi_2O_3 Based Glass (wt%)	CuO (wt%)	Zinc Borosilicate Glass (wt%)	
38	68.7	21.035	10.265	3.00	—	—	Sintering Aid A
39	68.7	21.035	10.265	5.00	—	—	
40	68.7	21.035	10.265	7.00	—	—	
57	68.7	21.035	10.265	3.00	3.00	—	
58	68.7	21.035	10.265	5.00	5.00	—	
59	68.7	21.035	10.265	7.00	7.00	—	
42	68.7	21.035	10.265	3.00	—	—	Sintering Aid B
43	68.7	21.035	10.265	5.00	—	—	
44	68.7	21.035	10.265	7.00	—	—	
60	68.7	21.035	10.265	3.00	3.00	—	
61	68.7	21.035	10.265	5.00	5.00	—	
62	68.7	21.035	10.265	7.00	7.00	—	
45	68.7	21.035	10.265	3.00	—	—	Sintering Aid C
46	68.7	21.035	10.265	5.00	—	—	
47	68.7	21.035	10.265	7.00	—	—	
63	68.7	21.035	10.265	3.00	3.00	—	
64	68.7	21.035	10.265	5.00	5.00	—	
65	68.7	21.035	10.265	7.00	7.00	—	
48	68.7	21.035	10.265	—	—	3.00	Comparative Example
49	68.7	21.035	10.265	—	—	5.00	
50	68.7	21.035	10.265	—	—	7.00	

FIG.48

Sample No.	Shrinkage Rate (%)	Sintered Body Density (g/cm^3)	μ' (500MHz)	μ'' (500MHz)	Additive			
					CuO (wt%)	Sintering Aid A (wt%)	Sintering Aid B (wt%)	Sintering Aid C (wt%)
38	14.77	4.50	2.67	0.05	—	3.0	—	—
39	15.96	4.74	2.52	0.04	—	5.0	—	—
40	16.42	4.84	2.25	0.03	—	7.0	—	—
57	15.92	4.77	3.12	0.08	3.0	3.0	—	—
58	16.77	4.92	3.08	0.08	5.0	5.0	—	—
59	16.69	4.91	1.92	0.03	7.0	7.0	—	—
42	11.89	4.22	3.37	0.03	—	—	3.0	—
43	13.39	4.42	3.60	0.04	—	—	5.0	—
44	14.04	4.53	3.37	0.04	—	—	7.0	—
60	14.12	4.52	3.47	0.15	3.0	—	3.0	—
61	15.81	4.79	3.80	0.39	5.0	—	5.0	—
62	16.31	4.87	2.72	0.17	7.0	—	7.0	—
45	11.15	4.18	3.46	0.02	—	—	—	3.0
46	12.66	4.37	3.81	0.09	—	—	—	5.0
47	13.38	4.39	3.43	0.07	—	—	—	7.0
63	13.50	4.46	3.55	0.18	3.0	—	—	3.0
64	15.23	4.70	3.88	0.42	5.0	—	—	5.0
65	15.54	4.73	2.88	0.223	7.0	—	—	7.0

FIG.49

Sample No.	Permittivity ε	Bi_2O_3 Based Glass (wt%)			CuO (wt%)	Bi_2O_3 (wt%)
		Sintering Aid A	Sintering Aid B	Sintering Aid C		
38	27	3.0	—	—	—	—
39	30	5.0	—	—	—	—
40	28	7.0	—	—	—	—
57	31	3.0	—	—	3.0	—
58	31	5.0	—	—	5.0	—
59	30	7.0	—	—	7.0	—
42	22	—	3.0		—	—
43	25	—	5.0		—	—
44	23	—	7.0		—	—
60	26	—	3.0		3.0	—
61	27	—	5.0		5.0	—
62	27	—	7.0		7.0	—
45	21	—	—	3.0	—	—
46	24	—	—	5.0	—	—
47	24	—	—	7.0	—	—
63	25	—	—	3.0	3.0	—
64	26	—	—	5.0	5.0	—
65	26	—	—	7.0	7.0	—
56	40	—	—	—	5.0	5.0